LIVERPOOL

GEOLOGICAL ASSOCIATION.

JOURNAL.

VOL. XII.

SESSION 1891-92.

LIVERPOOL:
J. DONALD, PRINTER, 495, PRESCOT ROAD, OLD SWAN.

1892.

LIVERPOOL GEOLOGICAL ASSOCIATION.

JOURNAL.

VOLUME XII.

SESSION 1891-92.

LIVERPOOL:
PRINTED FOR THE ASSOCIATION BY J. DONALD, 495, PRESCOT ROAD,
OLD SWAN.

1892.

The Authors alone are responsible for the facts and opinions expressed in their respective Papers.

INDEX.

LIVERPOOL GEOLOGICAL ASSOCIATION,

FREE LIBRARY, WILLIAM BROWN STREET, LIVERPOOL.

Established 3rd June, 1880.

Council, 1891-92.

President:

DANIEL CLAGUE, F.G.S.

Vice-President:

T. R. CONNELL.

Members of Council:

A. NORMAN TATE, F.G.S.
CECIL F. WEBB, L.D.S.
C. E. MILES.
REV. SAMUEL GASKING, B.A., F.G.S.
ROBERT STOREY.

Treasurer:

W. H. MILES, 9, The Woodlands, Birkenhead.

Secretary:

JAMES PATERSON, 13A, Richmond Street.

THE ABOVE FORM THE EXECUTIVE.

Librarian: MR. R. W. B. ROBERTS.

Liverpool Geological Association.

LIST OF MEMBERS.

HONORARY MEMBERS

Dawkins, Professor W. Boyd, M.A., F.R.S., F.G.S. .....Manchester.
Dawson, Sir J. W., LL.D., F.R.S., &c. .....Montreal.
Hughes, Prof. T. McKenny, M.A., F.R.S., F.G.S. .....Cambridge.
Judd, Prof. J. W., F.R.S., F.G.S. .....London.
Semmons, W..... .....London.
Woodward, H., LL.D., F.R.S., F.G.S. .....London.

ORDINARY MEMBERS.

Ashley, R. H. ..... 15, Stanley Street.
Ashton, F. W..... .....
Atkinson, W. L..... 51, Oxton Street, County Road, Walton.

Banister, H. C. ..... Elmhurst, Blundellsands.
Barber, J. M. ..... 4, Eyes Street, Breckfield Road, North.
Beasley, H. C. ..... Leam Cottage, Wavertree.
Brennan, Thomas ..... 127, Granton Road.
Brown, Jos. ..... 37, Exe Street.

Clague, Daniel, F.G.S., (President.)... 68, Sandstone Road, Stoneycroft.
Conlon, Bernard..... 22, Mount Pleasant.
Connell, T. R. (Vice-President.) ..... 31, Islington.
Cresswell, F. O. ..... 73, Stuart Road, Walton.

Daken, John ..... Melville Chambers, Lord Street.
Davies, S..... 6, Edith Street, Anfield.
Davies, J. Butler ..... 25, Belgrave Road.
Davies, David ..... 56, Dorset Street, Hulme, Manchester.

Deuchar, P. B..... Exchange.
Dickson, Edmund, F.G.S. ..... 30, Eastbourne Road West, Birkdale.
Duff, Samuel ..... Endowed Schools, Grey Southern, Carlisle.

Evans, E. ..... Aughton.
Evans, J. C..... Albany Chambers, Lord Street, Southport.

Fowler, Thomas Richard ..... Elsdon, Cumberland Road, Liscard.

Gasking, Rev. S. B.A., F.G.S.,
(Council.) ..... Skelmersdale.
George, Isaac E..... 16, Wynnstay Street.
Gregson, G. E., M.E..... 34, Brackenbury Road, Preston.

Harvie, W..... 110, Kirkdale Road.
Hancox, John ..... 101, Prescot Street.
Henson, Samuel .... 97, Regent Street, London, W.C.
Hewitt, William, B.Sc ..... 16, Clarence Road, Devonshire Park, Birkenhead.
Holbrook, The Hon. Henry..... Parkgate, near Chester.
Hornell, J..... Jersey.
Howarth, G. A. ..... 2, Wellington Road, Waterloo.
Hunt, T. S. ..... 7, Island Road, Garston.

Jones, J. Herbert .... Derby Terrace, Huyton.
Jones, W. A. .... 65, Lorne Street.
Jones, D. ..... 42a, Vernon Street.

Kelly, J. Dunbar ..... 4, Sweeting Street.

Lewis, A. E. ..... 74, Rogerson's Quay, Dublin.
Lister, R. F ..... 155, Prescot Road.

McFall, S..... ..... Bankfield Road, Stoneycroft.
Maguire, T. ..... 108, Landseer Road.
Marrow, P. H ..... 8, St. John's View, Seacombe.
Miles, Charles E. (Council.) ..... 57, Willow Bank Road, Higher Tranmere, Cheshire.
Miles, W. H. (Treasurer.)..... 9, The Woodlands, Birkenhead.
Moore, T. J., C.M.Z.S..... The Museum, William Brown Street.
Morris, John ..... Sir Thomas's Buildings.

Paterson, James (Secretary.) ..... 18, Normanby Street.
Potter, Charles ..... 101, Miles Street.
Pritchard, A. R. ..... 201, Bedford Road, Bootle.

Ranford, Miss S. ..... 25, George's Road, West Derby Road.
Reade, T. Mellard, C.E., F.G.S.,
F.R.I.B.A. ..... Park Corner, Blundellsands, Lancashire.
Ricketts, Charles, M.D., F.G.S. ..... 18, Hamilton Square, Birkenhead.
Roberts, R. W. B. (Librarian.) ..... 5, Melrose Road, Kirkdale.
Roberts, Thos. D. ..... 4, Handfield Place.
Rundell, T. W. ..... 25, Castle Street.

Scott, Mrs. S. ..... 56, Irlam Road, Bootle.
Shaw, S. H., M.D. ..... 23, Prince's Avenue.
Shilston, Thomas, M.I.N.A., F.G.S. 31, Westmoreland Road, Newcastle-on-Tyne.
Staley, Miss B. C. ..... Seafield, New Brighton.
Storey, Robt. (Council.) ..... Imperial Chambers, Dale Street.

Tapscott, R. L., F.G.S ..... 62, Croxteth Road.
Tate, A. Norman, F.G.S., (Council) ... 9, Hackins Hey.
Thomas, Hopkin ..... Kinglake Street.
Timmins, Arthur, C.E., F.G.S. ..... Argyle Villa, Runcorn.

Ward, Thomas, F.G.S. ..... Brookfield House, Northwich, Cheshire.
Webb, Cecil F., L.D.S (Council) ..... 2, Brougham Terrace, West Derby Road.
Webb, John R. ..... 2, Vernon Place, Birkenhead.
Wescott, H. ..... 94, Prince's Road.
Wigzell, Miss M. ..... 32, West Derby Road.
Wilding, J. ..... 118, Earle Road.
Wilson, H. M. ..... 11, Aspen Grove.
Williams, Miss L. ..... 55, Rocky Lane, Newsham Park.
Williams, Richard ..... 12, River Avon Street.
Williams, T. H. ..... 2, Chapel Walks.
Williamson, W. ..... 10, Dinorwic Road, Anfield.

Liverpool Geological Association.

ADDRESS TO MEMBERS.

The past year was a real success, and notwithstanding our somewhat reduced numbers, members may congratulate themselves on the position of our Association, inasmuch as we have had an accession of enthusiastic working geologists, whose contributions are to be found in the Journals issued.

Before long our eleventh vol. of Transactions will be ready for distribution amongst the various learned societies with whom we exchange, and we venture to say it will not lose by comparison with its predecessors. But for the all-important matter of expense it would be well to revive what was once a pleasant and profitable feature of it, viz., notes of procedure and discovery in the scientific world, with short articles on geological subjects. But until funds are considerably increased our desires in that direction must remain in abeyance.

As it is the earnest wish of your Council to foster a spirit of inquiry into geological science, and by all means within reach to increase the sum of knowledge stored up by those who have gone before, it was, at a recent meeting, unanimously resolved to appoint Committees for the accomplishment of certain work during the current year, one of these being for the prosecution of petrological microscopy, consisting of four members, with power to add to their number. The first report was presented on the occasion of our recent meeting, when Mr. C. F. Webb (Chairman) described the composition of a boulder found at Bootle by Mr. Pritchard, as exhibited in sections prepared by the latter gentleman.

Another small but important Committee has been formed to work in conjunction with the Librarian, and from the

report of the Chairman on Monday last, their task of re-arranging and re-cataloguing books is so well advanced that the volumes will be ready for issue next meeting.

Of greater numerical strength is the Committee chosen for the purpose of collecting facts and reporting progress in the matter of the cave deposits at Little Ormes Head. Mr. Robert Storey, the Chairman of the Committee, being on the spot during some portion of each week, has a favourable opportunity of observing every change by blasting operations, and of noting any fresh finds as the rock is removed. This new and interesting field for work has attracted much attention on the part of several of our members, and arrangements have been made for a systematic record of the work of the Committee as it proceeds.

Last, but by no means the least important, of the Committees is that selected to undertake the appointment of excursions to places of interest, so that members may together study our particular science in its most instructive of all aspects—the physiographical. An expressed desire on the part of members for some conjoint system of working on the glacial deposits of our neighbourhood will be considered by the Council on an early date; in the meantime, those who are desirous of taking part in such work should communicate with the Secretary.

In reference to our monthly meetings, we are pleased to state that a number of papers are already promised, but as there are yet vacancies, the Secretary will be glad to hear from any member who may be desirous of addressing the Association on any phase of geology.

Altogether, an interesting Session may be anticipated. Our hope is that attendance at the monthly meetings will be such as to denote a more widespread concern in the subject of our studies than has been displayed during the late past.

By Order of the Council.

November, 1891.

ORDINARY MEETING,

Held at the Free Library, William Brown Street, Monday, 2nd November, 1891, the President, Mr. D. Clague, F.G.S., in the Chair.

NOMINATIONS.—Mr. W. Scott Walker, 22, Derwent Road, Stoneycroft, and Mr. T. W. Craine, 4, Bold Street, were nominated.

COMMITTEES.—The Secretary read the following list of Committees which have been appointed by the Council, the first-named on each Committee having been appointed Chairman:—

Publication: J. PATERSON, D. Clague, and A. N. Tate.
Excursion: C. E. MILES, J. Paterson, and R. Storey.
Library: T. R. CONNELL, J. Brown, and D. Clague.
Mr. R. W. B. Roberts, Librarian.
Petrological Microscopy: C. F. WEBB, R. W. B. Roberts, A. R. Pritchard, and D. Clague.
Little Ormeshead Cave: R. STOREY, J. Paterson, C. F. Webb, D. Clague, G. A. Haworth, and T. R. Connell.

Mr. B. Conlan then exhibited by oxy-hydrogen lantern an interesting collection of geological slides, including views of the Isle of Wight, glacier scenery, and a series of photographs of various places at which the Association has held field meetings during the summer months. These were briefly introduced by Mr. W. H. Read, the photographer. As the places were well known to the members, a free conversation took place on the geological features brought out by the pictures, and the various problems involved in them.

This was essentially a *member's* meeting, when those who had never read papers took an active part in conversation.

DEATH OF SIR ANDREW C. RAMSAY, LL.D. F.R.S. F.G.S.

We pause for a moment to note that one of the Veterans of our Science has just passed away. Wherever Geology is studied the name of Ramsay will be a household word. Well known as sometime Director General of the Geological Survey of Great Britain, which distinguished post he held for ten years; but perhaps better known as the Author of "Physical Geography and Geology of Great Britain," a book well known and highly prized and which has done much to assist students to understand and read correctly the records of the great stone book.

He was essentially a *Field Geologist.* It was in the field he worked out the problems which account for the origin of the mountains and valleys of Wales, and which enable the traveller not only to admire the rugged scenery, but to read therein the history of the past. In the field too, he worked out his theory of the glacier origin of lakes, which has been and still is a bone of contention amongst us; however we may differ as to the theory, there can be no question about the facts which he observed, and it needs a practical Field Geologist to produce *facts* to shew that *some* lakes owe their origin to other forms before his theory can be overturned, and even with such facts his opponents would only succeed in shewing that the theory is not universally applicable. Independent careful observers and clear reasoners command the respect of their fellow students, and such a one was Sir A. C. Ramsay, who died 9th December, 1891.

ORDINARY MEETING,

Held at the Free Library, William Brown Street, Monday, 7th December, 1891, the President, Mr. D. Clague, F.G.S., in the Chair.

ELECTIONS.—Mr. W. S. Walker and Mr. T. W. Craine were elected members.

NOMINATIONS.—Mr. William Owen, 35, Bolton Street, and Mr. John J. Craine, 165, London Road, were nominated for membership.

Mr. W. H. Read read a Paper on "Fresh Water Mussels," which was illustrated with diagrams shown by the optical lantern.

THE FRESH WATER MUSSEL.

BY W. H. READ.

(Abstract.)

The term fresh water mussel includes the *Anodonta*, which is a bivalve mollusc inhabiting our lakes and pools, and also the *Unio* of our rivers.

ANATOMY.—In speaking of the valves or shell, we describe the height as measured from the bosses or umbones, from which its growth commences, to the opening of the valves; the length is taken from anterior to posterior extremity. In many bivalves just below the umbo is a depressed space termed the lunule; this marks the anterior end, the opposite rounded end is the posterior end; between this and the umbo we have the elastic ligament or hinge, so marking the dorsal or superior border; opposite to this is the ventral edge or border.

Turning to the interior of the valve, we observe markings at each end, where the adductor muscles were attached. In some shells there is only one adductor muscle scar; in this Anodonta there are two, hence the shell is known as *Dimyarian*. The impression of the pallium or mantle is also seen in the curved line which unites the muscle scars; the pallium line makes a distinct incurve at the posterior end, indicating that the siphon tubes of the animal are well developed.

The mantle is that part of the animal which lines the shell, and is seen on the ventral part; within it, on either side, are two gills with a medial foot, by means of which the animal is enabled to make journeys over the soft mud or sand, leaving a broad triangular furrow behind.

The heart is situated dorsally in the vertical plane, and consists of a ventricle and two lateral auricles. Two aortæ distribute the blood, breaking it up into capillaries and sinuses, and are continued into veins which pass through the organ of Bojanus and the gills to the auricles.

The Anodon is acephalous, or without a head. Its mouth is situated close to the anterior adductor muscle, and has two labial palpi on either side; the æsophagus leads up to the stomach, which is surrounded by the liver; from thence the alimentary canal descends into the foot, in which it performs many coils, then ascending just above the anterior adductor muscle, it passes as the rectum through the centre of the ventricle opening out into the cloacal cavity.

The gills, consisting of pairs of laminæ, give to the whole family of which the fresh water mussel forms part the name of Lamellibranchiata.

The nervous system has three pairs of ganglia—cephalic, pedal and parieto-splanchnic.

The ova which are fertilized in the gill cavities of the female develop into glochidia, which are ultimately cast out of the siphon tubes by the exhalent current. These glochidia have sharp incurved teeth on their valves, by means of which they attach themselves to the fins and tails of fishes, and are thus carried for a considerable distance before they finally drop off and settle down to a sedentary existence like their parents.

HISTORY.—This family of the mollusca is very ancient, for, early as the Cambrian period the various bivalved animals seem to have flourished; but it was not till the Old Red Sandstone rocks are met with that we find the fresh water mussel. In rocks of this epoch we have *Anodonta Jukesii*, found in Ireland, associated with the remains of ferns and other land plants, together with fragments of fishes such as are characteristic of the Old Red of Scotland. This shell closely resembles the modern Anodonta, and so opens out to the cultivated imagination a striking picture of Continental scenery, with a long series of lakes stretching away far as the Old Red Sandstone rocks extend—from Ireland, through Scotland to the shores of Norway.

The next indications we have of the fresh water mussel are found in the Coal Measures. Some geologists think that the Anthracosia belongs to this family; that, however, can scarcely be, as its affinities are with the Cardinia, a marine animal, and its remains are associated with Goniatites and Aviculo-pecten, both marine. Possibly another shell found in the coal measures—the Anthracomya—may be a fresh water mussel. In shape it is more like the Anodon than the Anthracosia, and the conditions prevailing during the growth of the coal-forests would be favourable to the existence of such a class of animals, the ground being intersected with rivers and streams, with ponds and pools of fresh water at intervals.

From this, through the long period represented by the Permian, Trias, Lias and Oolitic systems, we have no traces of fresh water mussels—not that we have any right to assume that they were not existing, but those deposits being of a marine character, are such as are not likely to yield traces of fresh water organism. An exception, however, must be made in favour of the Lower Oolites, which have a marine character in the South of England, but in the Midlands appears to be estuarine. And there we have Unio associated with such marine forms as Ostrea.

When we come to the Purbeck beds, the changed conditions due to a considerable upheaval of our country—when lakes and rivers again became features in the geography of Britain—again we find fresh water mussels; but now it is the river mussel Unio, of which there are 50 fossil species, which may be grouped around the *Unio Waldensis*, which is specially characteristic of the Wealden beds of Kent and the Isle of Wight, and directs our attention to the time when that part of Britain was submerged beneath the waters of a great estuary rivalling that of the Ganges or Nile for size, and which must have been fed by a mighty river which would require a continent as its gathering ground.

Then came the great depression, when East and South England were submerged beneath the waters of a Mediterranean Sea, and we lose sight of both Unio and Anadon till the re-elevation in Eocene times, at the close of which period fresh water conditions prevailed again in some parts of Hampshire, and the Unio is found once more. And again, in the Pliocene period, from which time we have a gradual merging of Britain to the conditions now prevailing, when Unio frequents our rivers and Anodonta inhabits our lakes and pools.

ORDINARY MEETING,

Held at the Free Library, William Brown Street, Monday, 4th January, 1892, the President, Mr. D. Clague, F.G.S., in the Chair.

ELECTION.—Mr. W. Owen and Mr. J. G. Crane were elected to membership.

EXHIBITS.—Microscopic section of Aberdeen granite, which was described by Mr. Roberts.

Stone implements and fossil teeth were also exhibited by members, and a tray of pre-historic remains, lent by the Museum Committee to illustrate Mr. Barber's Paper.

A Paper was read by Mr. J. M. Barber, entitled

"PRE-HISTORIC MAN."

(Abstract.)

Man is, geologically, the creature of yesterday. Of his earlier conditions and character we have no written records, but we have traces of him in the wrecks of the past, in the midst of which are occasionally found some traces of his handiwork, and from which we may learn something of his character and surroundings.

A study of these fragments has led many students to divide his history into three stages—*stone*, *bronze*, and *iron*. The two latter merge into the historic period; we, therefore, have now to study man specially as seen in the "stone age."

The relation of the various ages mentioned are represented in the contents of the Danish peat beds, in which four zones have been identified, the lowest containing fragments of Scotch fir, and the next, in ascending order, fragments of the Sessile oak. In both of these beds are found stone implements of human manufacture; above them are fragments of

pedunculate oak, and in these beds implements of bronze are found. The topmost beds contain beechwood and implements of iron. As the beech flourished in Denmark at the time when Rome was in the zenith of her glory, it is clear that the contents of the lower beds must carry us much further back in the history of mankind.

Some light is thrown on these peat beds by a study of the Danish shell mounds which are found along the coasts of most of the Danish islands, and which very much resemble the mounds of shells and other kitchen refuse in Georgia and Massachusetts, familiarly known as kitchen middens.

In these Danish mounds are flint knives, stone hatchets, and other implements of stone, wood, horn and bone, with fragments of coarse pottery, but no implements of bronze or iron. Clearly they belong to the stone age; the bones found in them all belong to animals of the historical period, but the molluscan shells are larger and thicker than those found in the Baltic Sea to-day, thus indicating that some considerable geographical change has taken place since the formation of the mounds.

The deposits in Swiss lakes are usefully studied in this connection. Herodotus tells of the Roumelians living in houses constructed on platforms, which were supported by stakes driven into the lake bottom (520 B.C.) This throws much light upon the fragments of wood, some of it charred by fire, which is associated with piles in the bottoms of the Swiss lakes, which represent a period much more remote than that of which Herodotus wrote. There are, in some cases, two sets of piles, one younger than the other, and in the mud at the lake bottom are implements of bronze, and at a lower level implements of bone and stone. The eastern lakes contain no bronze, but only stone implements polished, and with them fragments of coarse plaited cloth, carbonised wheat, flat round cakes of bread, bones of the dog, ox, sheep and goat, carbonised apples and pears, and quantities of hazel nuts.

BELGIUM.—In caves near Leige human bones have been found associated with those of animals now extinct, such as the cave bear, and with those of animals which, though they still exist, do so no longer in these Northern countries—as the elephant, hyena, and rhinoceros. Bones of the horse and reindeer have also been found, flint implements of the dressed and polished type were common, and in one cave was found a polished needle-shaped bone with a hole drilled through one end.

FRANCE.—In this country we find two distinct sets of deposits of the pre-human period—the river gravel and the cave deposits. The river gravels are well represented in the valley of the Somme, where there are a succession of gravel beds at various heights on the sides of the valley, indicating the successive levels of the river as it was gradually cutting the valley deeper; consequently, the higher gravels will be the oldest and the lower gravels the more recently formed. In these gravels, at both upper and lower level, remains of the mammoth, bear and rhinoceros have been found, along with many implements made out of stone by human agency.

Some of the caves seem to have been places of habitation, as that of Perigard, which contains teeth and bones of the mammoth, Irish elk, cave lion, and antlers of the reindeer; these antlers have been carved, no doubt, by the original inhabitants of the cave. The tusk of the mammoth is also decorated with an engraved picture of the animal itself, with its curved tusks and remarkable covering of wool and long hair.

The climate of this period seems to have been much colder than is represented by the contents of the shell mounds of Denmark: no metal implements are found in these French caves, and the implements are of the rough, unground type.

Some of the caves seem to have been used as places of burial only, as the grotto of Aurignae, inside of which have

been found the remains of 18 human beings, a few ornamental bones, and unused flint knives. On the ground outside the cave many bones have been found, some broken, scratched, or burned, as if they had formed part of a funeral feast.

BRITAIN also furnishes us with some material out of which to weave the story of pre-historic man. The Brixham caves, near Torquay (described in Transactions of our Association, vol. 1, p. 49), have yielded bones of extinct animals and many flint knives; so also have the Biddenham gravel pit caves in Mendip Hills, the caves of Gower in Glamorganshire, and many other localities.

From all which we glean that the stone age may be subdivided into two stages—the earlier or Paleolithic stage, characterised by rough, unpolished implements; and a later, or Neolithic age, marked by carefully dressed and even polished stone implements.

The men of the first age seem to have been of a massive build. The skull of the Cro Magnon cave shows great brain development, the great breadth of face and the masticatory muscles give the idea of a violent and brutal character. There is no evidence that they cultivated the ground, but they were hunters, armed with spears tipped with flint or bone; they carried daggers of reindeer's horn, also bows and arrows. Pottery does not seem to have been known amongst them. Their raiment must have been skins of wild beasts, their ornaments shells and teeth.

The newer or Neolithic race of men appears to have been smaller built and of more settled habits: with their remains we find traces of domestic animals, as the dog, sheep, short horned ox and pig; fragments of rude pottery, traces of cloth, polished and well finished implements, indicating an advancement in the arts of peace, as do also the traces of agricultural pursuits.

ORDINARY MEETING,

Held in the Free Library, William Brown Street, on Monday, 1st February, 1892, the President, Mr. D. Clague, F.G.S., in the Chair.

Papers were read by Mr. R. W. B. Roberts on the "Microscopic Characters of Quartz;" Mr. Richard Williams, on "The St. Erth Beds at Hayle, Cornwall;" and by the President, on "Diamonds found in Meteorites."

THE MICROSCOPIC CHARACTERS OF QUARTZ.

QUARTZ is one of the most abundant of minerals. It has been calculated to form 35 per cent. of the earth's crust. It occurs in nearly all the crystalline, igneous, and metamorphic rocks, and porphyritic crystals are also found in a great many volcanic and intrusive rocks, such as rhyolites, andesites, pitchstones, quartz-porphyries, &c.

It crystallises in the form of hexagonal prisms and pyramids. Owing to the fact that in the crystalline rocks containing quartz this mineral has been the last to consolidate, its form is allotriomorphic, or, in other words, its outlines are not crystalline. It merely fills the interspaces between the other minerals present. In the case of porphyritic crystals, however, microscopic sections frequently show hexagonal outlines, although the crystals have often been much corroded by the action of the fluid magma in which they floated prior to the consolidation of the rock.

Sections of quartz appear black under reflected light. By transmitted light they are clear and colourless, but are

characterised by the presence of large numbers of minute cavities and mineral inclusions. The cavities are usually filled with either liquids, gases, or glassy matter. It frequently happens that those containing liquids or glass are not quite full; in such cases small bubbles may be seen, which are movable when the cavity contains a liquid, and fixed when glass is the infilling matter. The liquid is generally water holding gases in solution, and occasionally containing cubes of salt, these latter proving the presence of chloride of sodium in solution. The minerals which occur as inclusions in quartz are chiefly rutile and chlorite. The cavities are understood to be indications that the quartz crystallised under great pressure, which prevented the gases and water from making their escape.

With polarised light quartz gives bright colours, such as yellow, red, and blue, which vary in intensity according to the thickness of the section, the thickest slices giving the deepest colours. Sections cut perpendicular to the principal axis of the prism, and examined between crassed Nicols, show what is called a uniaxial interference figure, consisting of a black cross, with concentric rings.

R. W. B. ROBERTS.

NOTES ON THE ST. ERTH BEDS.

ST. ERTH is a small village near Hayle, and stands about 75 feet above the level of the sea. The beds, which are about to be described, stand some 30 feet higher. The formation consists of gravel, sand and clay, and is exposed in a pit near the Vicarage. The south side of the pit contains fine, pale sand, used for foundry purposes, and is worked to a depth of about 20 feet, with two feet of loamy clay, full of angular stones, forming the land surface. The sand on the north of the pit forms the basement bed, upon which the fossiliferous

blue clay was deposited to a thickness of nine feet, with a thin layer of yellow clay above. Next in order are fine gravel and coarse ferruginous sand from three to five feet thick. Intercolated in these sands and gravels is a black, coarse, gritty sand, coloured by an earthy oxide of manganese, over which lies the loamy clay, with angular stones from two to three feet thick, forming the sub and surface soil.

While looking at the beds in situ, they range in colour from nearly white, through the various shades of brown, yellow and bright red, to black; they also vary in degree of coarseness, from the minutest grains to coarse gravel.

In the Pliocene period, after a long exposure as a land surface, during which a continuous subærial denudation was in progress, Britain underwent a local subsidence, and these beds were laid down prior to, or contemporaneous with, the early deposits of the Red Crag. The fauna show decidedly a more southern facies than the fossils found in the upper Red or Norwich Crag. The blue clay is very fossiliferous, and some species are found in great numbers—for instance, Cerithia are numerous at the base, while the Nassa and Turretilla are generally distributed. The bivalves are in a more fragmentary condition, the univalves being better preserved. It is interesting to note the large number of the smaller species of mollusca, especially the gasteropods, that are found in that bed. The peculiar feature of these beds is, the Boreal and Arctic species found in the crags are absent at St. Erth, and the southern species found in the above are absent in the eastern crags. The following are characteristic of the St. Erth beds: Fusus corneus, Nassa recticostata, Nassa serrata, Nassa mutabilus, Cardium tuberculatum, Cardium papillasum, Cardita aculeata, and Nucula sulcata. The genera Rissoa and Odostoma are most plentiful.

There is thus evidence of a great difference in the climate of the eastern and western deposits of Britain in the crag age.

The percentage of northern species in the Coralline Crag is under 5 per cent., those in the Norwich Crag are over 16 per cent.

Mr. R. G. Bell, F.G.S., in a paper read at the meeting of the British Association at Manchester, says: "Had there been any connection with Northern seas, or colder waters, it would be difficult to understand the entire absence of those forms of Pleurotoma so abundant in the Boreal seas of the crag period and the present age, as well as the equally characteristic bivalves, Astarte and Cyprina."

The crags being on the North Sea, they would naturally be affected by the Arctic current much sooner than Cornwall on the West coast. Nor are we sure that England was separated from the Continent of Europe at that time; but if so, the Boreal species would take longer to travel to the West of England than to the East.

The geographical position of the Crags and St. Erth beds will go a long way to explain the difference of fossil contents, especially taking into consideration the gradual change of climate.

The remarks of Mr. Bell lead to the conclusion that England was united to the Continent of Europe during the Pliocene period, and what is now the German Ocean was then an inland sea, which had no communication with the Atlantic through what is now the English Channel. To these remarks a serious objection might be taken if we lost sight of the fact that the fossils differed materially on the East and West coast. Is it not probable that the area now occupied by the North Sea was submerged, and the communication established with the Arctic Ocean enabling the Boreal species to spread over the East Coast without affecting the fauna on the West? Further, let us suppose that Scotland extended far beyond its present limits, and was nearly, if not quite, united to Iceland.

Would not this form a formidable barrier to the cold current entering the Atlantic? The western shores of England would be kept warm by the influence of warm equatorial currents, and the temperature more genial during Pliocene time on the western coast than on the eastern, the latter being swept by a cold current from the Arctic regions, which was destined, with other physiographical changes, to bring about glacial conditions in Britain in the succeeding Pleistocene period. The increasing proportions of northern species in the Crags and later formations may be taken as an indication that the climate was gradually becoming colder.

As to the mode of deposition, I venture to put forward a theory, as a scientist without a theory is like a preacher without a text—not much good.

Before the subsidence and deposition of these beds a river must have drained the country to the east-north-east, and emptied itself through what is known as the Weir of Hayle into the sea. At the present time the tide makes its way through this opening in the embankment, and stretches itself out to the right and left for a distance of about a mile and a half on either side. On the St. Erth side there is a tide-washed area some three quarters of a mile wide, which extends beyond St. Erth.

The Local Board of Hayle has adopted means for making this area into a kind of dock, and some of the tradesmen have made wharves at the backs of their premises at which can be unloaded large coasting vessels; this they have been enabled to do by cutting a deep waterway. I mention this in order to show that the subsequent upheaval was not equal to the depression, or did not extend over the same area. Is it not probable that the depression which occurred was sufficient to engulf the low lying area of St. Erth? Had the Devonian rocks on the coast suffered a similar depression the sea might have extended a mile further inland, but such was not the

case, and the only means the sea had of entering the background was through the old river channel, which would naturally result in a large inland bay with a narrow entrance.

Subsequently a great incursion of sand must have taken place, which had been previously formed at the mouth of the river and on the sea shore, spreading over the submerged land and forming the basement bed of foundry sand. After a lapse of time, and, doubtless, some physical change in the features of the country, a stream brought in suspension the material to form the clay deposit, which was precipitated in a few fathoms of water.

I do not think that a great depth of water is at all necessary for the deposition of the clay, especially in the situation we have under consideration. There are two points to be considered—first, that the clay is the result of denudation of some of the surface rocks, and carried away by running water, which was deposited as soon as the velocity was checked; second, that the scene of deposition was invaded by sea water is certain from its fossil contents. Now suppose the whole area of St. Erth was covered with sea water, which had only a narrow communication with the sea. A most ordinary and casual observer must have noticed the struggle which takes place between tidal waves and fresh water currents. Streams do not flow straight into the sea and are lost, but often flow parallel with the shore, sometimes forming themselves into huge tongues dividing the sea water. It was at this junction, and under similar circumstances, the clay deposit took place, when the force of the water holding it in suspension was checked by the contending sea water.

We need not go far for the source from whence the material was derived to form the deposit. In the county there are large granite districts, and the effect of atmospheric water on the soda and potash felspars would result in the production of kaolin. Assuming that the clay was formed

from the decomposition of the felspars in granite, the quartz grains would be liberated to form the sand, and the colour was undoubtedly supplied from some of the metaliferous deposits.

All the material requisite to record the history of the Pliocene period on the West coast of Cornwall is at once forthcoming. Claim has been laid to the deposition of these beds in a partly enclosed bay. While doing so two facts have been kept in view—first, the disturbing influence of the oscillating wave and heavy Atlantic swell; second, the depth necessary for so finely divided material to be precipitated into the sea. Had the material been laid down in the open ocean it would have been carried far beyond the littoral into the thalassic zone, where the disturbing influence became more feeble as the water deepens and spreads out over a large area, because the finely divided matter out of which the clay has been formed remains for a long time suspended in water before sinking to the bottom. Then, again, the distance from the shore where the deposit took place would be increased over which the finely divided sediment suspended in river water is distributed, owing to the smaller specific gravity of fresh than salt water. From this cause the discharge from a river floats on the top of the sea for many miles, possibly over a hundred, before it becomes fairly mixed up with the salt water, and of course carries along with it its burden of suspended matter.

If we consider the clay deposit to have taken place in a sheltered part of a large bay, with a narrow entrance, then the quietness of the deposition of these beds is favourable to the preservation of the remains of animals. Hence the question arises—If they were formed out at sea, how are we to account for the fragmentary condition of some of the mollusca? the material in which they are embedded being so well calculated to preserve the shells.

The fossils militate against any such depth of water as would be required for the deposition of these beds in the open sea, they being nearly all littoral species, which may also account for the broken bivalves by supposing that they died where they lived, and were carried by the tides after death of the animals and washed into the clay.

To accept the theory of a partly confined bay will harmonise more with the fossil contents and the formation of the material.

RICHARD WILLIAMS.

ORDINARY MEETING,

Held in the Free Library, William Brown Street, on Monday, 7th March, 1892; the Vice-President, Mr. T. R. Connell, in the Chair.

NOMINATION.—Mr. G. D. Stenhouse, 28, Keble Road, Bootle.

EXHIBITS.—Limestone Fossils from Little Ormeshead, by Mr. Robert Storey.

A Paper was read by Mr. Edmund Dickson, F.G.S., on "The Triassic Rocks of Cannock Chase: a comparison between them and the Triassic Rocks of South Devon, Lancashire, and Cheshire."

ORDINARY MEETING,

Held in the Free Library, William Brown Street, on Monday, 4th April, 1892; the President, Mr. D. Clague, F.G.S., in the Chair.

ELECTION.—Mr. G. D. Stenhouse was elected.

NOMINATION.—Mrs. E. Clague, of 5, Sandstone Road, was nominated for membership.

EXHIBITS.—Mr. R. Storey exhibited a Bronze Spear Head, which had been recently taken out of the cave deposits at Little Ormeshead, and gave some interesting particulars about the position in which it was found, which, with other information, will be incorporated in the report of the

Committee. Mr. Craine (through the President) exhibited a number of boulders taken from the boring at Point of Ayr, Isle of Man, being portion of the new land formed there by the action of the sea current. An interesting conversation ensued about the origin of these boulders—the denudation of Jurby Point, and the probability or otherwise of finding Coal in the Isle of Man.

The following Paper on the Apatites of Cornwall should have been read; but not having arrived from the author, the Publishing Committee were instructed to have it printed and in the hands of the members in time to be discussed at the next meeting:—

THE APATITES OF CORNWALL IN RELATION TO THEIR ENVIRONMENTS.

By William Semmons.

The series of changes undergone by that apparently obdurate class of rocks known as Granites has during the past few years received much attention from petrologists.

The formation of Kaolin or China clay, which formerly was supposed to result from the action of surface waters, has now been proved to be largely owing to Plutonic agencies. In addition to this change, the researches of Bonney, Judd, Teall and others have revealed to us many alterations in structure and composition not previously suspected. It has occurred to me that a few remarks on the recent find of Apatite crystals and the character of the granite in which these are found might possibly be of interest.

These are found in the Eastern boss of granite near the village of St. Blazey, and close to the locality of Luxalyan, where occur the boulders of that remarkable rock,

Luxalyanite, described by Professor Bonney in the *Mineralogical Magazine*, vol. 1. It may be remembered that this is the rock of which the sarcophagus of the Duke of Wellington was made, and of which the parent rock is not known, although boulders of great size are scattered over the locality.

The granites of Cornwall, as were well described by Sir Henry de la Beche, are like three islands rising out of a sea of clay slate. The largest, or Eastern mass, forms the *locale* of the present paper, and is the largest of the three.

The Apatite crystals have been discovered in the quarrying of the granite for commercial purposes, and I may add that, although crystals of this mineral have been found in each of the three bosses, there has never yet been sufficient of the mineral met with to have any economical value. The crystals are by far the largest ever yet raised in England, some being three inches long, although, as a rule, they range from microscopic dimensions to half an inch in length. They have a most brilliant lustre, and quite equal in this respect the magnificent specimens from Untersalzbachthal, in the Tyrol, which are the show stones of many important collections on the Continent. The colour varies from emerald green to bluish green, and many of the crystals have finely banded lines of colour indicating gradual layers of deposit.

To one acquainted with Apatite crystals, their distinctness of habit when from different localities is easily apparent. Those from the Tyrol, Saxony, Canada and Norway all seem to have their special characteristics. Again, those from St. Michael's Mount have a facies peculiar to themselves. But, strange to say, in this new locality we have the short, unmodified, hexagonal prisms of the Saxony habit, the finely modified forms of the Tyrol, and, again, the long beryl like forms met with in some German mines. In fact, some of the latter might easily be mistaken for beryls.

Some of the crystals have a large number of facets, and present almost a gem-like appearance. I have one with 46 faces shown. They occur scattered over the surface of large crystals of Orthoclase, which latter have evidently been altered considerably in character; also, deposited on lustrous black crystals of Tourmaline, and also occasionally on the altered quartz crystals of the granite.

The associated minerals are—Orthoclase in large crystals; Felspar in small crystals, resembling Clevelandite, apparently a secondary deposit scattered over the surface of the Orthoclase; Tourmaline in two varieties—(1st) long, black crystals penetrating the Orthoclase and quartz, and on which the Apatites sometimes occur, (2nd) thin brownish crystals, which seem to be of the same age as the Apatites, which sometimes completely envelop them; Gilbertite in little rounded masses, which encrust the Orthoclase, quartz, and black Tourmaline (I do not consider the identity of this mineral is yet fairly established); quartz of the original granite, in some cases eaten away and much altered; Quartz in clear crystals, evidently a later deposit; Stilbite in small brilliant crystals, found scattered over the Gilbertite, though only rarely; Calcite and Fluorspar. We will examine these various minerals in further detail, as they throw some light on the probable formation of the Apatite.

The Orthoclase.—This occurs in fine distinct crystals up to six inches or more in length, which are very seldom twinned. Almost always they are altered for a small distance below the surface to a yellowish mineral having somewhat the appearance of undurated kaolin. In some cases the crystals are corrugated and pitted, and bear unmistakably marks of being acted on by some chemical agency. Occasionally they are largely impregnated with long bladed crystals of lustrous black Tourmaline, and in some cases the original Felspar crystals have been almost entirely destroyed.

Gilbertite.—As before stated, I do not consider the identity of this mineral has been fully established. It is undoubtedly a lustrous yellowish white mica, and occurs in spherical clusters, and lies over the surface of the Orthoclase, but has been deposited after it, and therefore represents a secondary deposit.

Cleavelandite.—This occurs in brilliant white crystals on the surface of the Gilbertite, and is evidently a much later age than the Orthoclase. This is further proved by the fact of its covering the crystals of Apatite occasionally.

Tourmaline.—As might have been expected when we meet with a granite that has been acted on, we find this mineral present. In fact, Cornish granites seem rarely free from it for any considerable area. In the present case we find long bladed, thick, lustrous black crystals, which penetrate the felspar and quartz of the original granite, and seem to be intimately connected with the cause of alteration; and secondly, we find thin crystals of a dark brown colour, which are of later age. I wish to draw particular attention to the latter variety and its mode of occurrence. The granite, when first quarried, is extracted in very large blocks, and these are cut into pieces of the size required for the market. On splitting one of the larger blocks, which, to all appearances, was a solid piece of granite, over a bushel of lumps of Tourmaline fell out on the ground, leaving a large cavity, and, of course, proving that particular block of rock to be useless for its intended purpose. These lumps of Tourmaline were found to consist of myriads of small crystals, which were aggregated together in small bundles, and these bundles interlaced in every direction. One might compare them to bundles of matches stuck together at one end and open at the other so as to fit into another bundle. A mass of these crystals is now deposited at the British Museum. It should be noticed that for some little distance around these lumps of

Tourmaline the granite seemed quite rotten, though the outside of the block (perhaps 2 feet off) did not reveal any such sign. The chemical action here appeared to be local.

Quartz.—Although, as might have been anticipated, this obdurate mineral does not show such great changes as the Felspar, yet they are not the less convincing that such change has taken place. Many of the crystals are etched and eroded by the action of acids, and in some cases they have been eaten out so as to leave only an outside core. Many crystals, too, have finely divided Tourmaline pervading them, whilst some appear to be broken through by larger crystals of the mineral. There are indubitable proofs of great internal stress and strain in the presence of cracks that do not reach the outer surface of the crystals. In some cases we have a core of an older crystal, which has been etched and bears distinct traces of chemical action with a newer deposit thereon of clear pellucid quartz. This new deposit follows the original polarity of the crystal, though evidently of much later age, and conforms to the law laid down by Professor Judd in his paper on the "Rejuvenescence of Crystals." Some interesting planes are met with on these newer crystals, one of which, described by Miers (*Mineralogical Magazine*, No. 39), from my collection, had never previously been noticed.

Stilbite.—The occurrence of this zeolitic mineral is of interest, as it is not often met with on granite. It occurs in small brilliant crystals, scattered over the Gilbertite. I look on it as a proof of hydrothermal action.

Fluor.—In Cornwall one naturally expects to meet with Fluor Spar in the presence of Apatite and Tourmaline, and this locality forms no exception to the rule. Crystals of charming colours are met with, the predominating hues being purple or green, and often showing bands of varying intensity. Crystals up to 1½ inches are met with, and their forms are

usually cubes or octahedra, with planes occasionally of the rhombic dodecahedron, the ordinary four-faced cube planes being never met with as far as I have seen. The habit of these crystals is thus different from crystals of any other English locality.

Calcite.—This occurs sparingly in large, thin, hexagonal plates, like those from Andreasburg, in the Hartz. It seems to be a late formation.

Before proceeding to discuss the probable origin of these Apatite crystals I will briefly refer to some found in other localities in the same county. It might, however, be noticed that the secondary minerals—Apatite, Fluor, Calcite, and Stilbite—are all of them compounds of lime; so it is evident the Felspar must have contained lime if they have been derived therefrom, of which there can be little doubt.

Stenna Gwyn, situate in the same mass of granite, but some miles distant, is a famous locality for interesting minerals. The rare mineral Fluellite is here met with—*i.e.*, the fluate of alumina. The Apatite from this locality is found in blueish green modified crystals, and also in long hexagonal crystals of beryl habit. Gilbertite seems to be the most common associate, though Tourmaline is also met with in this altered granite.

Near Trewavas Head, in the middle island of granite, are found small brilliant crystals of Apatite associated with Tourmaline, and from Wheal Breage Mine, in this district, small green hexagonal prisms of the beryl habit are met with, associated with Cassiterite, Gilbertite and Tourmaline.

The Apatites of St. Michael's Mount are worthy of the lovely little spot where they occur. They are found in brilliant dark blueish green crystals, highly modified with topaz and a variety of mica, and until the St. Blazey find they were

unapproached by any other Cornish variety for beauty of form and colour. A large number of minerals occur in their immediate proximity, including Cassiterite, Wolfram, Tourmaline, and those before named.

At St. Just, in the extreme West of the county, some crystals of Apatite, with a poor lustre and of a yellowish brown colour, are found embedded in a garnet rock, but I have not studied these sufficiently to draw any deductions as to their probable origin, except to remark that again Tourmaline is met with in their neighbourhood.

Bovey Tracey was once a famous locality for Tourmaline, and the finest crystals of this mineral ever raised in England came from here. Associated with this mineral were large numbers of Apatite crystals of a brownish grey and flesh colour, which were generally doubly terminated hexagonal prisms, with few modifications. This was not strictly in Cornwall, being on the Eastern slope of the Dartmoor granite range, in Devon.

The above constitute all the examples I propose to submit from the granite, and I shall now bring forward some examples which have been found in the veins of some of the metalliferous mines of the county.

Francolite, from Wheal Franco, is described in all books on Mineralogy. I would only remark that these lovely little crystals are frequently found encrusting quartz which is pseudomorphic, showing chemical change has been actively at work. The beautiful sherry coloured crystals at the British Museum are worthy of notice.

Fowey Consols yields two varieties of Francolite—a name frequently applied to Apatite found in Cornish mineral veins, and, in my opinion, without reason. One of these, in curved hexagonal crystals of small size, has generally Chalybite

deposited thereon. The other, in simple prisms, has been found to contain a small percentage of carbonic anhydride. They are found with copper pyrites, and are described by Maskelyne and Flight.

In the St. Just Mines crystals of Apatite are met with (again called Francolite), associated with calcite and copper ores. These have been described by Solley in the *Min. Mag.*, vol. 3.

St. Day United Mines.—This group of mines includes some of the most famous mines of the county for copper ores, being where the beautiful Arsematites, Siroconite, Chalcophyllite, Olivenite, &c., were met with. About 27 years ago I found a large number of clear crystals resembling quartz scattered over the surface of Green Chlorite masses which encrust crystals of Quartz and Fluor. On examination they were ascertained to be hexagonal crystals of Apatite, having well-defined pyramidal terminations. These crystals are about $\frac{3}{8}$ inch long and $\frac{1}{16}$ inch diameter; and two very good examples are to be met with in the British Museum collection, the locality being unknown to the authorities till I examined them. They are associated with Wolfram and Cassiterite, and are from the veins or lodes that are worked by the miners at about 800 feet below the surface.

At Camborne Vean Mine, which lies at the western end of the celebrated Dolcoath Mine, an interesting deposit of Apatite crystals was met with at about 1000 feet below the surface. They are hexagonal crystals, with a curved surface almost precisely similar to those from Fowey Consols in habit, and like them of small size, being rarely $\frac{1}{4}$ inch across. On the Apatite are found crystals of Chalybite which present many interesting modifications of the Rhombohedron—one of them in fact closely resembling the regular Octahedron. This form is derived from the acute Rhombohedron by truncating the two acute ends.

At Tincroft Mine, about two miles east of Camborne Vean, and on probably the same lodes, at about 1000 feet below the surface, Apatite crystals are found similar in size and habit to those from Camborne Vean. On these, occasionally, Chalybite has been deposited. In fact probably some of the most brilliant and perfect crystals of Chalybite ever found were discovered here about five years since. The associated minerals are Cassiterite, Fluor and Hematite.

At Carn Brea Mine, which lies immediately to the east of Tincroft, an interesting series of Apatite crystals is met with. These do not resemble the Camborne Vean and Tincroft varieties, but are very similar in habit to those from the St. Just Mines. They are of a brown colour, in thin hexagonal plates, and in some cases are $\frac{7}{8}$ inch across and about $\frac{1}{16}$ inch thick. They are found in hollow pseudomorphs of Quartz after Fluor, and, strange to say, have a deposit of Chalybite crystals on them similar to the other mines in the district. They also are found at about 1000 feet below the surface.

The last four varieties are in my own collection, and have never previously been described. I would only wish further to point out that these veins are in Granite which contains Tourmaline and the fact that a Carbonate (of Iron) is found on them as a later deposit.

The conclusions that I have arrived at as to the formation of these Apatite crystals in the mineral veins is that the Plutonic waters have been charged with the Phosphate of Lime, and that they represent internal chemical agencies and do not in any way point to an origin from pre-existing animal life. The after deposition of Chalybite or Calcite from carbonated waters is the natural sequence in all regions where heated springs are met with in volcanic regions. There is no trace of volcanic action in any of the

districts described in this paper; but the occurrence of Granite and of Slates or Shale metamorphosed thereby is sufficient proof in my opinion of their being under the influence of the internal heat which is in some cases made manifest by the presence of volcanoes or hot springs and their deposits of Sinter. The sequence of events—so graphically described by Judd—occurring in the dying out of the internal fires, though complicated by the presence of metallic ores, are fairly analogised in these vein deposits.

The origin of the Apatite crystals in the Granite clefts appears to me to be very clearly demonstrated. We meet in every case with Tourmaline; we also find the crystals of Felspar to be decomposed; we further find that a secondary deposition of Felspar has been made; we further find the Quartz crystals have been acted on by some active chemical agency. All these point to the Granite as the ultimate source, though the Lime has not actually, as far as I know, been found in the unaltered Felspars of the locality.

Tourmaline, which is a Fluo-Silicate containing Boric acid, almost always contains Phosphoric acid. Hence we have all the constituents ready for the formation of the Apatite, and also for the Fluor spar, which so frequently accompanies it.

Boric acid is one of the most common emanations at the close of a period of volcanic energy, and these manifestations occur generally most clearly at the fringes of Granite areas where they are in contact with the sedimentary rocks. In this respect all the Cornish localities I have named are in complete accordance with those which have been examined elsewhere. I do not look on Apatite as an original constituent of the Granites, but as an after product caused by Hydrothermal action.

My only regret is that I am unable to appear personally to thank the members of this Association for their extreme kindness in asking me to give some remarks on a subject in which we are united as workers; and I do this the more, as the fragile character of the minerals do not allow the risk of transit, and consequently prevent my sending specimens for their examination.

Let me, however, invite one and all of the members to pay me a visit when in London, and then verify or otherwise from contact with the stones themselves the conclusions at which I have arrived.

ORDINARY MEETING,

Held in the Free Library, William Brown Street, on Monday, 2nd May, 1892; the President, Mr. D. Clague, F.G.S., in the Chair.

ELECTION.—Mrs. E. Clague, of 5, Sandstone Road, was elected.

EXHIBITS.—Mineral specimens from Valcahuano, Chili, by Mr. J. R. Webb.

A paper was read on

"THE TRIAS OF CHEADLE & ALTON, STAFFORDSHIRE."*

BY H. C. BEASLEY.

[ABSTRACT.]

The district to which this paper refers lies immediately south-east of the Potteries, between the main line of the North Staffordshire Railway and the Churnet Valley line.

After leaving the Potteries and passing through the Mere Tunnel, the appearance of the cutting shows at once that the Coal Measures have been left behind, they having been cut off by a fault bringing down the Bunter, which is soon followed by another, bringing down the Keuper which forms the rich level of grazing land which stretches away on the right or south-west of the line.

Leaving the railway at Blyth Bridge and walking along the road to Cheadle, one or two roadside sections of the lower Keuper are seen. Just before entering the village of Fosbrook the basement beds of ths Keuper may be seen in a channel at the roadside, followed by the upper Bunter. Better sections may be seen up a narrow lane on the opposite or left hand side of the road. The lower Bunter here is, Mr. Hull says (Permian and the Red Sandstone Rocks of the

* Being notes of a short excursion made in August last by the Author, accompanied by Messrs. C. E. Miles and F. R. Chalmers.

Midland Counties), the farthest eastern extension of this division, as beyond this the Keuper rests on the Pebble beds.

Just before reaching the second milestone from Cheadle, a farm road on the left leads to Callow Hill farm. Passing through the farmyard to the top of the hill we found some gravel pits giving good sections of the Bunter conglomerate, which here assumes the character of gravel just sufficiently consolidated to stand in a vertical face, and is very similar to that at Cannock Chase, lately described to this Association by Mr. E. Dickson. The pebbles are of the same character, mostly quartzite, well rounded, but averaging slighty less in size than those of Cannock Chase, and they are generally pitted in the same manner where one pebble has been in contact with another. One pebble of calcareous grit was found containing organic remains apparently of a small cephalopod, as the septæ and siphunicle were clearly defined. Neither here nor in the Cannock Chase conglomerate have I seen any fossiliferous quartzite pebbles like those found at Budleigh, Salterton. There were some thin seams of sand seen in this section and traces of current bedding in the gravel.

Owing mainly to the evening closing in, we were unable to see the junction of the conglomerate with the Coal Measures as we passed down the hill towards Cheadle; but there is no doubt the conglomerate lies directly on the latter.

On the top of the hill, on the south side of which the town of Cheadle is built, there is a gravel pit giving a very good section:—

	ft.	in.
Soft Sand and Gravel	1	6
Gravel	2	0
Soft White Sandstone with Quartz Pebbles	3	6
Gravel	5	0

The Gravel is just like that at Callow Hill, and is in places distinctly current-bedded.

Looking at the range of hills that encircle Cheadle, the junction of the Bunter with the Coal Measures is easily traced along the hill sides, as the smooth slope of the latter gives place to the deeply-furrowed surface of the former. The difference in the vegetation is also strongly marked, the green fields covers the Coal Measures giving place to the bracken, heather and pines that grow on the Bunter.

The day following our arrival at Cheadle we walked through Tean to Hollington, where there are extensive quarries in the Keuper of a well-known building stone. About half way to Tean a road section shows a part of the Bunter pebble beds that here resemble those of our own district. Whether these be above or below the gravels we were unable to tell. Entering Tean a fault, invisible, is crossed, and the village is seen to be built on the Keuper building stone, to which, as we ascend the hill toward Heath House, the Marls succeed. Across the part that surrounds the house the line of a fault is traceable bringing up the Bunter pebble beds covered with pine woods, as they here reassume their gravelly character. On reaching the top of the hill the road runs along the gravelly ridge, whence there is an extensive view on either side. A mile or so farther on the quarries at Hollington are reached. There are some on the right-hand side of the road, but the principal ones form a semicircle round the back of the hill on the other or north side. The character of the stone somewhat resembles that of Storeton, but the quarries are less cut up by faults—and they are very picturesquely situated just below the ridge on the steep side of a hill.

The quarry nearest the high road showed the following section :--

	ft.
Drift	12
Soft Sandstone with few pebbles	5
Sandstone without pebbles	6
,, with pebbles	4
,, Building Stone with Marl partings.	25

The measurements are estimated.

With reference to the top bed, which I have called drift, at first sight it looks like the Bunter conglomerate; but a difference very soon strikes the eye. The matrix is softer, more marly and redder, and the stones on the whole smaller, though the mineral constituents are the same. It is evidently composed of material from the conglomerate mixed probably with pebbles and marl from the Keuper. The top of the Keuper seemed very uneven, and the capping of drift varied from 10 to 20 ft. thick.

There seemed a large number of Quartz and quartzite pebbles and fewer clay galls than with us in the Keuper. I saw one small but rather perfect footprint and other traces of them. They may have belonged to a Rhynchosaurus, but more probably to a smaller lizard.

Leaving the quarries, we returned along the valley to the north of our former route; but presently, in crossing the hills to Cheadle, we came across gravel pits, in one of which we found a bed consolidated into stone, probably by some calcareous matter being present.

The following day we walked from Cheadle to Alton, first crossing a ridge of the Bunter conglomerate, and then coming upon the Keuper and crossing the heads of several deep, well-wooded ravines cut down through the Keuper into the Bunter. On our right, at a little distance, we saw Peakstone rock figured in Hall's Memoir—being a mass of hard Keuper conglomerate resting on a pillar of Bunter. Several quarries in the Keuper building stone are passed as the road descends to Alton village. There is a good road section on the hill between the upper part of the village and the railway station, and the junction of the Bunter and Keuper is seen. There are some 30 ft. of soft Bunter exposed with very few pebbles, and rather harder at the top, overlain by the hard conglomerate at the base of the Keuper, which

forms the cliffs that crown the escarpment on the right side of the valley for several miles.

There are a series of quarries to the rear of the escarpment east of the village. Besides building stone, they make grind stones for Sheffield. Some very indistinct and uncertain traces of Cheirotherium footprints and plant stems were seen in one of the marl partings. Crossing some fields on the top, we descended to the base of the cliffs, and found very good sections of the basement beds:—

	ft.
Freestone with pebbles	12
Conglomerate.....	12
Reddish Current-bedded Sandstones passing into freestone with some pebbles	6

The conglomerate is very hard and very full of small pebbles, mostly 1 inch or less in length, of Vein Quartz, Quartzite and Lydian stone, strongly cemented together, probably with Silica, as it does not effervesce with acid. The section varies greatly every few yards, owing to the want of persistence of the conglomerate. Below these beds was a soft stone, probably Bunter, but mostly hidden by vegetable growth.

In the escarpment west of the village the conglomerate contains much larger pebbles—many of them over 3 inches in length.

Going along the road from Oakamoor, just before reaching the opening to Dinnisdale, a large fault is seen at the roadside bringing the Bunter conglomerate against the upper beds of the same division, and, I believe, higher up the hillside, against the Keuper; there are several good sections of the conglomerate on the roadside between this point and Oakamoor Station, in one of which we saw about 12 ft. of the conglomerate between beds of soft sandstone with pebbles. At Oakamoor Station our short excursion ended, and we returned thence to Liverpool.

ORDINARY MEETING,

Held in the Free Library, William Brown Street, on Monday, 4th July, 1892: The President, Mr. D. Clague, F.G.S., in the Chair.

NOMINATION.—Mr. W. B. Barr, of 2, Barrington Road, was proposed for membership.

EXHIBITS.—*Productus Longispinus*, Iceland Spar, &c., from Holywell, by Mr. T. R. Connell.

The following communication from Mr. W. Semmons, in extension of his Paper on the

"APATITES OF CORNWALL,"

was read.

"Since the Paper was written, I have seen the quarries, and find the Granite is strongly jointed. One set of joints, the main, run nearly due E. & W. magnetic, and another set crosses them at an angle of about 70 degrees. There are also planes of bedding which the men call lines of strata, which run almost parallel to the slope of the hill.

In one large block—about 15 feet, 6 by 4 ft.—there were no less than three large cavities, over 6 inches across, out of which nests of Tourmaline had fallen, and which still retained numbers of fine crystals of this mineral adhering to the sides.

Another block, in which I detected a thin black line, was broken open, and a large cavity found therein, containing Apatite, Tourmaline, and altered orthoclase.

A further point of interest was revealed by the discovery of a crystal of Felspar, in which this mineral seemed to be altering into Mica, as there were numberless small silvery crystals along the basal cleavages. This is a point to which I hope to give further attention."

A Paper was read on

"TERRA COTTA,"

by Mr. J. Wilding.

ORDINARY MEETING,

Held in the Free Library, William Brown Street, on Monday, the 5th day of September, 1892: The President, Mr. D. Clague, F.G.S., in the Chair.

ELECTION.—Mr. W. B. Barr, of 2, Barrington Road, was elected.

NOMINATION.—Mr. Harry Thomas, 15, Cheapside, Liverpool, was nominated for membership.

EXHIBITS.—3 vols. of Cuvier's "Animal Kingdom," by Dr. Cecil F. Webb.

AUDITORS.—Messrs. Herbert Jones and W. B. Barr were elected Auditors.

Mr. W. H. Miles then read his

"NOTE ON SUPPOSED 'FOOTPRINTS' FOUND AT RUNCORN."

(Illustrated by numerous specimens of the impressions to which reference was made.)

During several recent visits made to the Runcorn Quarries by Mr. Beazley, my brother and myself, we have come across some pieces of slabs with curious markings, suggestive of footprints—though, in appearance, very unlike the well-known footprints of the Trias. A casual examination of the specimens shows that they possess some unusual features. Some are marked with what looks like the impression of *Bark*, the pittings being $\frac{1}{8}$ in. to $\frac{3}{4}$ in. diameter. Others have irregular pittings that might be taken for rain pittings, but are ill-defined in outline.

With regard to these latter, I think it possible that something similar has been noticed by Mr. Strahan in the Geological Memoir of the locality, where he says:—"The sun-

cracks and ripple marks are preserved in these beds in great perfection; but the pittings which accompany them resemble, in a few instances, only those which are produced by rain. Indeed, the frequency with which they occur in connexion with the suncracks points to so constant an alternation of sunshine and shower as to render this explanation of their origin suspicious. It is possible that in some cases they have been produced by the escape of gases from a moist surface of mud freshly exposed to a hot sun. Somewhat similar markings are produced by this cause in the tidal mud of the Mersey at every ebb tide."

The most striking of the casts are more singular in their appearance. They exhibit what I can only describe as a "knobbly" shape, the footprint, if it be such, being quite unlike any of the familiar types. Some specimens look like the impression of one or more slender clawed toes from 1 to 1½ inches long.

It is probably owing to the fact of their unlikeness to footprints generally that these curious marked slabs have hitherto been unrecorded. It can hardly be that they have been unnoticed, as the locality is well known and frequently explored by geologists. They are so numerous as to render it improbable that they can be mere freaks or accidental surface distortions, for though the markings are obscure and in some cases ill defined, there is a constancy in the patterns which are frequently repeated even to obscure details.

The specimens were found in the old disused quarry on the hill at the north west corner. The beds are Keuper I believe, but whether Upper or Lower I have not been able to determine. We found them plentifully in the spoil heaps, and on one occasion Mr. Beazley and I traced them to an adjacent bed in the quarry, out of which we dug a piece showing the characteristic markings—though an imperfect specimen, this Mr. Beazley secured. This bed is seen exposed on a ledge of rock which has been a good deal broken up, apparently by others in search of specimens. The slabs exposed show ripple mark-

ings, and are separated by a thin clay seam from a thick compact sandstone which has on its upper surface numerous nodules or segregations of either Iron or Manganese, which weather out beautifully.

Other footprints of the orthodox type have frequently been found at Runcorn—some fine specimens found last year are now located at the University College in Ashton Street. It does not follow of course, that all come from the same bed, and I am disposed to think that the specimens now shown have come from a different bed to that from which the Cheirotherium footprints have been obtained.

It is in the hope that other members may search for and may succeed in securing other and better marked specimens, that I have ventured on describing those already found. Other specimens may throw light on the true nature of these, and it is desirable that as many as possible should be obtained for purposes of comparison.

The points to be settled, if possible, by future researches are:—

1. Confirmation of their position *in situ*.
2. The position of the beds from whence they are derived in relation to the Keuper formation and to the other "Footprints beds."
3. The exact nature of these impressions and their relation, if any, to the well known "footprints."

I may add that the quarry is by no means exhausted of specimens, which are to be found by turning over and examining likely looking slabs in the spoil heaps.

FIELD MEETINGS.

HOLYWELL.—Whit-Monday, June 8th. Conducted by the President. On this visit we went over the ground traversed on a former occasion, *(see Journal, vol. 8, p. 70)* devoting, however, more time to work in the Carboniferous Limestone. The special matter worthy of note was finding portions of Lime-

stone with the same needlelike pearly rods which were exhibited at a meeting of the Association some time ago, and referred to on March 3, 1890, *(Transactions, vol. 10, p. 23)* and which then were not understood, but now are proved to be detached spines of Productus Longispinus.

Duncorn.—June 18th. Conducted by Mr. C. E. Miles, who subsequently gave a report of the day's work in a paper at the Ordinary Meeting held 5th September. *See p. 43.*

Kirkby Moss.—Saturday, 6th August. Conducted by Mr. T. E. George, covering the ground traversed on a former occasion. *See Transactions, vol. 5, p. 75.*

Broxton.—Saturday, 20th August. Conducted by Mr. W. H. Miles. Again old ground was gone over. *Transactions, vol. 4, p. 7, and vol. 9, p. 64.*

Alt Mouth.—Saturday, 3rd September. Conducted by Mr. T. R. Connell, going over the ground worked in 1890. On this occasion, however, specimens of the vegetable remains found in the peat were brought away and exhibited at the next Ordinary Meeting.

Wallasey.—Saturday, 17th September. Conducted by the President. Attention was first drawn to the junction of Lower Keuper with Upper Bunter, near the church. The next study was the various indications of movement of the rocks subsequent to their consolidation, noting first the contorted rocks in Brook Road. *(See Transactions, vol. 2, p. 84, and vol, 8, p. 65.)* The wedge shaped mass containing the marked crumpling was examined on the underside, which was found to have been smoothed by friction on the underlying rock, proving a lateral thrust. At Poulton Quarry other indications of rock motion were visible in the slickenside on the rocks. Attention was also directed to the indication of glacial action.

Liverpool Geological Association.

ANNUAL MEETING,

Held in the Free Library, William Brown Street, on Monday, 3rd October, 1892: The Vice-President, Mr. T. R. Connell, in the Chair.

Election.—Mr. Harry Thomas, 15, Cheapside, was elected to membership.

The Annual Report of the Council and the Financial Statement of the Treasurer were read, as also were Reports from the various Committees, and, on the motion of the Vice-President, unanimously adopted.

The following Officers and Council for the year 1892–93 were then elected by ballot:—

President: Mr. D. Clague, F.G.S.

Vice-President: Mr. T. R. Connell.

Treasurer: Mr. W. H. Miles.

Secretary: Mr. A. R. Pritchard.

Council:

Mr. Cecil F. Webb, D.D.L.,

Mr. Joseph Brown,

Mr. J. Herbert Jones,

Mr. C. E. Miles,

Mr. James Paterson.

Annual Report, 1891-92.

Another year of the Association's existence having drawn to a close, your Council have, in the ordinary course, to report on the work done since last Annual Meeting, and on the position of the Society at the present time.

During the year there have been 8 elections, 9 resignations, and 7 members struck off under Rule 2, while 1 has been removed by death, leaving the number on the roll at 75, viz., 6 honorary and 69 ordinary members.

Ordinary Meetings were held on the first Monday of each month, excepting general holidays, when the following Papers were read and discussed:—

"The Fresh Water Mussel," by Mr. W. H. Read.
"Prehistoric Man," by Mr. J. M. Barber.
"St. Erth Beds" at Hayle, Cornwall, by Mr. Richard Williams.
"Triassic Rocks of Cannock Chase," &c., by Mr. Edmund Dickson, F.G.S.
"The Apatites of Cornwall," by Mr. Wm. Semmons.
"Trias of the Cheadle and Alton District, Staffordshire," by Mr. H. C. Beasley.
"Terra Cotta," by Mr. Wilding.
"Note on supposed Footprint Bed at Runcorn," by Mr. W. H. Miles.

It is with a sincere feeling of regret your Council have to chronicle the loss of one of the oldest and best friends of the Association in the lamented demise of Mr. A. Norman Tate, F.I.C., F.G.S., &c. One of the early members of the Association, he, in course of time, became President, which

position he held until failing health dictated retirement. As one of the Council, and latterly as a member of the Publishing Committee, he was at all times ready to use his valuable time in the interests of the Association. His genial manners conjoined to an unusual generosity, will long be remembered by those who were under the necessity of consulting him in times of need.

The bound volume of Transactions for the previous year has been forwarded to the various societies with whom we exchange.

The Library is now in good order, after much labour and devotion to the work on the part of the Librarian, Mr. R. W. B. Roberts, and the Committee. The Chairman, Mr. T. R. Connell, will present a full report of its present condition.

Reports from the Excursion, Little Ormeshead, and Petrological Committees, giving a synopsis of the work done during the year, will also be laid before you.

The Treasurer's Report, duly audited, is appended. It is satisfactory to know that we commence the new session free of debt, and with some good assets in hand. Subscriptions are now due, and your Council would urge on all an early discharge of the debt, so that the Committee may not feel hampered in publishing the transactions of the Association.

LIVERPOOL GEOLOGICAL ASSOCIATION in Account with the Treasurer

FOR THE YEAR ENDING SEPTEMBER, 1892.

Dr. Disbursements.	£	s.	d.
To Printing and Stationery, to August, '92	11	14	0
,, Postages and Incidentals, to September, '92, including Lantern Exhibitions for 3 yrs...	4	1	11
,, Rent of Room to May 2nd	1	15	0
,, Binding Library Books	0	18	0
,, Gratuity to Attendant	0	10	0
,, Balance in hands of Treasurer	0	3	1
	£19	2	0

Receipts. *Cr.*	£	s.	d.
By Balance from last year, viz.:—			
General Fund £1 16 10			
Library Fund..... .. .. 0 11 6			
	2	8	4
,, Subscriptions:—			
3 for year 1889-1890			
10 ,, 1890-1891			
51 ,, 1891-1892			
1 ,, 1892-1893 (in advance).			
65 Subscriptions at 5s.	16	5	0
,, Receipts from Authors for Printing	0	8	6
,, Sale of Pamphlet.....	0	0	2
	£19	2	0
By Balance	£0	3	1

Audited and found correct,

JOHN HERBERT JONES.
W. B. BARR.

W. H. MILES,
HON. TREASURER.

3rd October, 1892.

CONDENSED REPORT OF PETROLOGICAL COMMITTEE.

The Committee was formed in November, 1891, with the object of promoting an interest in the microscopic investigation of rock and mineral characters. Since its formation the Committee has examined in all 13 slides, all of which, with one exception, have been prepared by members of the Committee. The boulders from which the sections were taken were all from the Boulder Clay in the neighbourhood of Bootle. The reports are, therefore, contributions to the geology of the district.

The rock sections examined were:—Sanidine trachyte (2 slides), Aberdeen Granite, volcanic ash, pyroxene andesite (3 slides), vesicular andesite (3 slides), olivine basalt, and two slides of sand grains showing crystal growths. It will only be necessary to allude here to some of the most salient features of the slides, as the detailed reports will be kept in the Library of the Association, and will be available for reference.

The sanidine trachyte was the first section examined by the Committee, and was interesting on account of the rarity of trachytes in the British Isles. The Carlsbad twins of sanidine were very fine.

The section of Aberdeen Granite which was next submitted for study was remarkable for the evidence which it afforded of the rock having been subjected to severe strain. This was proved by the spectral polarisation or strain shadows in the quartz and by the micro-spectral polarisation in the felspar. It would, perhaps, be difficult to find a slide in which these peculiar phenomena would be more clearly displayed.

The volcanic ash was useful for the study of biotite, of which mineral numerous large crystals were present.

In the pyroxene andesite, three slides of which passed before the Committee, the effects of weathering were noticeable in the kaolinisation of the felspar, in the alteration of part of the olivine into serpentine, and in the large quantity of ferrite.

Three slides of a vesicular andesite were also examined. The chief interest in these centred in the vesicles, which were filled with calcite and chlorite.

R. W. BOOTHMAN ROBERTS, *Sec.*

EXCURSION COMMITTEE.

REPORT, 1891-2.

The Committee have to report some very pleasant and instructive Field Meetings held during the year, the only regrettable circumstance in connection with them being the limited attendance of members.

Our first visit was to Holywell on Whit Monday. The party had a busy time, and were successful in proving the origin of the spines found in the Limestone in that district.

Runcorn produced some casts which were exhibited to the members by Mr. W. H. Miles when he read his note on "The supposed Footprint Bed."

At Kirkby Moss the peats were studied.

The quarries at Storeton were especially interesting to those members who had not previously visited them. Alt Mouth, the site of a drowned woodland, exhibits the peat again on the estuary shore. At Wallasey, the goal of our latest ramble, we had the current bedding and crumpling, &c., so familiar a feature in the Trias rocks of our district.

The work done has given much enjoyment and some measure of profit to those students who, while endeavouring to read the records of the rocks, have, during the same time, rejoiced in the ever-changing pictures of earth, and sea, and sky.

J. PATERSON, *Sec.*

REPORT OF THE LITTLE ORMESHEAD COMMITTEE.

The Committee have, through its various members, visited the Cave from time to time and made many observations; but, as the work is still in progress, they are as yet unable to present a complete report.

The quarry is situated in the Trall-v-dd, on the east side of the promontory of Little Ormeshead, known locally as Trwyn-y-fuwch. The floor is 85 feet above the high water mark of spring tides. At a height of about 10 feet from the floor of the quarry there was observed a discoloured band on the face of the rock about 3 feet wide, which marked the situation of one of the subterranean passages which had been exposed by the quarrymen. This band inclined upwards at an angle of 40° to the spot where the bones, &c., have been found. About 40 feet above the floor of the quarry in this part there was observed a considerable quantity of cave earth mingled with the *debris* left by the quarrymen—forming a huge talus flanking the cliff,—in which we found a number of bones, &c. Many of the bones have not yet been studied, but the following have been identified:—

Portion of human jaw, with molar tooth.
Portion of upper and lower jaw of sheep, with teeth.
Vertebræ of sheep.
Molar of horse.

Molar of ox.
Also teeth of a rhinoceros and hyæna.
Portion of upper mandible and some small bones of a bird—probably a tern.
Tibia of a bird—probably a gull.

It is worthy of note that most of the large mammalian bones are broken, and associated with them are found shells of the Littorina and Patella, also Hazel nuts.

These facts lead us to suppose that this spot had been at one time the lodging place of human beings, who had carried the carcases of the larger animals for food purposes, with, perhaps, the exception of the hyæna, which would find its way along the various passages for purposes of its own.

This conclusion is confirmed by the presence of the Molluscs and Hazel nuts, and still further by the more recent find of a Bronze Spearhead.

A recent communication from Mr. Storey, who has gone to reside in the neighbourhood, shows that other passages are being exposed which may open out further work; and feeling that our work is incomplete, we recommend that another Committee be appointed to continue the research.

D. CLAGUE, *Sec.*

LIBRARY COMMITTEE.

The Committee appointed for the revision of the Library have to report as follows:—

Through the closing of the Library for a short period, in order to re-arrange same, the number of members availing themselves of its benefits has not been so large as in former years.

In the course of the year the Library has been enriched by donations and exchanges, lists of which are appended.

The best thanks of the Association are due to the donors, especially to the Yorkshire Philosophical Society for their proceedings from the year 1826 to the present time.

The number of bound vols. available for reference is 178.

In the course of the year, 12 vols. of Exchanges have been bound, and 16 vols. are now ready for the binder.

The Committee regret that a number of vols. of Transactions from kindred Societies are still incomplete, and hope that during the coming year this may be remedied, and the Library prove a further source of usefulness to the members.

For some time past the maps belonging to the Association have suffered through the want of a place for safe-keeping. This has been remedied by the action of Mr. Jos. Brown, a member of the Library Committee, who has kindly made and presented to us a cupboard in which they may be placed, and so preserved from further injury. The best thanks of the Association are due to Mr. Brown for his timely donation.

T. R. CONNELL, *Sec.*

DONATIONS TO THE LIBRARY, 1891–2.

Dr. Ricketts.—"On some Phenomena which occurred during the Glacial Epoch."

T. M. Reade.—"The Trias of the Vale of Clwyd, &c." "A Minature Illustration of Normal Faulting." "In Memoriam: Francis Archer." "Physics of Mountain Building." "Glacial Geology."

T. R. Connell, V.P.—British Association Report, 1882 and 1883. Murby's "Text Book of Geology." 2nd edition.

Also Transactions, &c., from the Societies marked with with an asterisk in the annexed list.

TRANSACTIONS

OF THE

LIVERPOOL GEOLOGICAL ASSOCIATION,

1891-92.

Copies of the *Journal* of the Association, Vol. XII., have been sent to the following institutions and societies, and exchanges received from those marked with a *.

GREAT BRITAIN & IRELAND.

*Birmingham Natural History and Microscopical Society.
Bristol Naturalists' Society.
Burnley Literary and Philosophical Society.
*Cardiff Naturalists' Society.
*Chester Society of Natural Science.
Cornwall Royal Geological Society, Penzance.
Cornwall Mining Association and Institute.
Cotteswold Naturalists' Field Club, Cheltenham.
Cumberland and Westmoreland Association for the Advancement of Literature and Science.
*Isle of Man Natural History and Antiquarian Society.
*Leeds Geological Society.
Leeds Philosophical and Literary Society.
Liverpool Engineering Society.
*Liverpool Geological Society.
Liverpool Literary and Philosophical Society.
*Liverpool Microscopical Society.
*Liverpool Naturalists' Field Club.
Liverpool University College.
London British Museum, N.H.D., Cromwell Road, S.W.
London Amateur Scientific Society.
London.—City of London College Scientific Society.

London Geological Society.
*London Geoligists' Association.
*Manchester Geological Society.
Manchester Microscopical Society.
Manchester Scientific Students' Association.
*Midland Naturalist, Birmingham.
Nottingham Naturalists' Society.
Norwich Geological Society.
Yorkshire Geological and Polytechnic Society, Halifax.
*Yorkshire Philosophical Society, York.
*Edinburgh Geological Society.
Glasgow Geological Society.
*Belfast Naturalists' Field Club.
Free Libraries, Barrow-in-Furness.
*Birkenhead, *Bootle, Liverpool, *St. Helens, Warrington.

AUSTRALIA.

*Australian Museum (The Trustees of the), Sydney, N.S.W.
Australasia Geological Society, Melbourne.
Victoria Department of Mines, Melbourne.

NORTH AMERICA.

Canada Geological and Natural History Survey, Ottawa.
*Nova Scotian Institute Natural Science.
*Geological Survey, Washington.
*Smithsonian Institution, Washington.
*Elisha Mitchell Scientific Society, Chapel Hill, N.C.
Wagner Free Institute of Science, Philadelphia.
Wisconsin Academy of Science, Art and Letters, Madison.
State Mining Bureau, California.